Internet of Things: Services and Applications

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Abstract

The Internet of Things (IoT) refers to a technological framework that enhances the potential for connectivity between individuals and devices. It has emerged as a significant opportunity to advance smart rehabilitation systems and contribute to the e-health sector. This study aims to identify research efforts involving IoT in the development, architecture, application, and implementation of technological tools aimed at patient rehabilitation. Technology or Method: A systematic review was conducted by Kitchenham's guidelines and the PRISMA protocol. The search was carried out comprehensively across the IEEE Xplore Digital Library, Web of Science, and Scopus databases, focusing on primary IoT and patient rehabilitation studies. The services and applications offered by the Internet of Things (IoT) are examined in this review article. IoT integrates various technologies beyond traditional connectivity, such as computing systems, networks, and sensors. The article divides IoT services into four primary categories to address the interoperability challenge: identity-related, information aggregation, collaborative-aware, and ubiquitous services. The article offers developers an organized framework to comprehend and optimize IoT services by examining these categories. By emphasizing accessible services and their useful uses, this framework seeks to expedite application development and promote the development and deployment of Internet of Things solutions.

Keyword: - *Internet of Things (IoT), Smart Rehabilitation Systems, e-Health Sector, Systematic Review, Interoperability*

1. INTRODUCTION

In 1999, Kevin Ashton coined the term "Internet of Things" (IoT) to describe the notion of linking intelligent devices to the Internet to facilitate data sharing and automated judgment [1]. IoT has changed dramatically since its beginning, gaining traction in various applications. Empirical evidence suggests that almost any object can be recognized, linked, and employed for information sharing, impacting decision-making procedures in several fields [2]. The interaction paradigms of human-to-human, human-to-thing, and thing-to-thing are all included in IoT communication [2]. The potential of this technology is enormous and extends to new trends like Industry 4.0, Blockchain, and Business Analytics, as well as applications in various industries like healthcare and education [3]–[6]. We are now in the era of the Internet of Things (IoT), having seen the evolution of the Internet from a technology primarily used to connect people and places to a complete infrastructure that connects a wide variety of devices. The Internet of Things (IoT) is a paradigm change in which almost everything in our surroundings, from industrial machinery to home appliances, is connected via a single network. This shift promises us ongoing insights into the condition of numerous connected things in addition to improved control over our environment IoT's enormous reach and complexity, however, come with a few difficulties. Internet of Things networks do not follow a standard architecture like traditional networks. Rather, it includes a wide range of sensors The Internet of Things, or IoT, is a cutting-edge technological paradigm that links a wide range of physical objects to the Internet so they can trade, gather, and process data on their own. This networked ecosystem of smart gadgets brings the digital to the real world, opening previously unheard-of possibilities for efficiency, creativity, and automation. IoT includes various services and applications, each tailored to handle requirements and difficulties in different industries.

Several essential service types, such as identity-related services, information aggregation services, collaboratively aware services, and ubiquitous services, are at the heart of the Internet of Things. Accurately tracking and identifying assets and devices requires identity-related services that make use of technology like RFID and biometric systems. Information aggregation services gather and combine data from various sources to provide insightful analysis and facilitate well-informed decision-making. Enhancing device collaboration and interaction is the main goal of collaboratively aware services, which use real-time data to optimize operations and results. The goal of ubiquitous services is to offer integrated, frictionless access to digital controls and resources for every facet of daily living. This review paper delves into the current landscape of IoT services and applications, offering a comprehensive analysis of their development, deployment, and impact. It explores the advancements in IoT technologies, evaluates their implementation in various domains such as healthcare, smart cities, agriculture, and industrial automation, and highlights the associated benefits and challenges. By examining recent research, case studies, and practical applications, this review aims to provide a thorough understanding of how IoT is transforming industries and everyday life. Additionally, it identifies emerging trends and future directions, aiming to inform researchers, practitioners, and policymakers about the potential and trajectory of IoT technologies.

2.TYPES OF SERVICES

The Internet of Things (IoT) encompasses a wide range of applications, from automating homes and offices to monitoring production lines and tracking products in retail environments. The potential for applications is vast and continually expanding. For each specific application, a dedicated IoT service can be utilized to enhance development efficiency and accelerate the implementation process. The following categorizations are adapted from [3].

2.1. IDENTITY RELARED SERVICES

Identity-related services can be divided into two types: active and passive. These services can be applied to both individuals and enterprises, resulting in a variety of different applications. Typically, an identity-related service involves two primary components: 1) the objects, each of which is fitted with some form of identification, such as an RFID tag; and 2) the reading device(s), which detect the identity of the object based on its tag, in this instance reading the information encoded within the RFID tag. The reading device then sends a request to a name resolution server to obtain more detailed information about the specific object.

Active identity-related services are those that transmit information, usually powered by a continuous power source or battery. Passive identity-related services, on the other hand, lack an internal power source and rely on an external device or mechanism to transmit their identity. For example, an active RFID tag is battery-operated and can transmit signals when an external source is detected. A passive RFID tag, however, does not have a battery and needs an external electromagnetic field to trigger signal transmission. Generally, active identity services can transmit or send their information to another device, whereas passive services need to be scanned or read.

2.2. INFORMATION AGGREGATION SERVICES

Information aggregation services involve gathering data from various sensors, processing it, and transmitting it via IoT to the application. These services typically operate in a one-way manner: data is collected and sent through the network to the application for processing.

Information aggregation services do not need to use a single type of communication channel to function together. By using access gateways (as illustrated in Figure 1), an information aggregation service can incorporate different types of sensors and network devices, sharing their data through a unified service to the application. For example, an application might use RFID tags to identify devices while also utilizing a ZigBee network to collect sensor data, with a gateway device relaying this information to the application under a shared service such as a Web Service using JSON or XML. This not only enables application developers to integrate various technologies into their applications, but also allows the application to connect with existing IT and enterprise services.

2.3. COLLABORATIVE-AWARE SERVICES

Collaborative-aware services use aggregated data to make decisions and then carry out actions based on those decisions. As IoT continues to advance, it is expected to lead to the creation of sophisticated services that make use of the vast amount of data available from a wide network of sensors. This will require not only the collection of information but also the ability to send responses back to the collected data to initiate actions. Such services will require both “device-to-device” and “device-to-person” communication. Providing collaborative-aware services will necessitate greater reliability and speed from the IoT infrastructure, and devices may need increased processing power or connection to other devices.

2.4. UBIQUITOUS SERVICES

Ubiquitous services represent the ultimate potential of the Internet of Things. These services would not only be collaborative-aware but would also be accessible to everyone, always, and across all devices. To achieve the level of ubiquitous services, IoT must overcome the differences in protocols among various technologies and unify every aspect of the network. While there is no specific system architecture for the Internet of Things, numerous studies have discussed the use of Web Services or REST (representational state transfer) APIs (application programming interfaces) to connect loosely coupled devices on the Internet under a single application so that they can be reused and shared. IPv6 is also a protocol that could significantly benefit the growth of ubiquitous services.

3.APPLICATIONS OF IOT SERVICES

Moving beyond the definitions of each category, the subsequent sections offer illustrative examples of each type of service. These examples are designed to provide developers with practical starting points for creating their own applications. By showcasing various scenarios, the goal is to present a diverse range of applications for each service type that employ common technologies. This approach aims to establish a foundational framework that developers can use as a basis for building applications tailored to specific service types. Additionally, these examples will help illustrate how different technologies can be integrated into applications, offering valuable insights and inspiration for innovative solutions.

3.1. IDENTITY-RELATED SERVICES

Even though they are straightforward, identity-related services are essential to any Internet of Things (IoT) application. These services allow developers to get important information about each item or device in their system. The most prominent instrument utilized in identity-related services is RFID technology. RFID enables the transmission of data from a tiny gadget called a tag, which is read by an RFID reader and processed in line with the needs of the application. Since RFID doesn't require a direct line of sight and, in the case of active RFID tags, can actively transmit data, it advances conventional identification techniques like barcode scanning. FID technology is used in the majority of IoT applications that use identity-related services. An RFID tag has a special identifying number that is specific to each device, as explained in [5].

After capturing this code, the RFID reader contacts the RFID server to obtain the specific data required for the application. Applications pertaining to identity, such as production and shipping, are highly advantageous. An identity-related service model, for instance, can handle information asymmetry problems in communication and supply chain management [6]. Since identifying connected objects is crucial, almost all IoT applications will include some sort of identity-related service to properly merge the physical and digital worlds.

3.1. INFORMATION AGGREGATION SERVICES

Wireless Sensor Networks (WSNs) and access gateways are two further components that information aggregation services add to identity-related services to gather and forward data to applications for processing. These services oversee sending the application with gathered and maybe processed data from system terminals (such as sensors and RFID tags). WSNs are useful for collecting and sending data between the application platform and terminals, given that the platform is in the WSN's coverage area. Nonetheless, a multi-WSN collaboration is usually required for a comprehensive IoT application. These networks are connected by access gateways, as seen in Figure 2. By connecting to the database server, every IoT gateway aggregates data from every device connected to the network. Access gateways and information aggregation services are used by many applications. To improve data accessibility, for example, [7] proposes employing cellular networks (CN) to extend the range of WSNs. When terminals are outside of the primary WSN range, this method entails employing an "IoT gateway" that integrates both WSN and CN resources to access data. Information aggregation services are useful for monitoring—for example, energy monitoring in residences and commercial buildings, or better yet, monitoring any environment at any location. As an illustration, [7] presents a greenhouse condition monitoring system that records temperature, humidity, and soil data and sends it to a central platform for analysis. Another example [8] uses an autonomous electronic medical record generator and a ZigBee WSN to monitor patient physiological data.

3.2. COLLABORATIVE-AWARE SERVICES

Utilizing gathered data to inform decisions and drive actions is the primary distinction between collaborative aware services and information aggregation services. Strong network security, fast connectivity, and sophisticated terminal processing skills are necessary for collaboratively aware services. Devices need to gather data, process it, and take appropriate action based on the information. IoT applications utilizing collaboratively aware services are less common. Nonetheless, it is anticipated that emerging technologies like IPv6 would develop these services. Because there are fewer IP addresses available, IPv6, the most recent version of the Internet Protocol, permits a much greater number of addressable devices, which is essential for the Internet of Things' future. The integration of objects into the IP infrastructure through 6LoWPAN (IPv6 over low-power wireless personal area networks) and IPv6 is suggested in Reference [9]. Three different types of nodes—mobile, specialized, and base station nodes—that can be reprogrammed for different purposes are part of their proposed network. Thanks to the IPv6 protocol, this configuration allows for both terminal-to-terminal and terminal-to-person communication, making it a collaboratively aware service.

3.3. UBIQUITOUS SERVICES

The aim of the Internet of Things is ubiquitous services, which expand collaborative-aware services to provide total access and control over everything in our surroundings, whether via PCs, smartphones, or other devices. While ubiquitous services are still in the early stages of development, current IoT research endeavours to facilitate the attainment of this objective. The difficulties in implementing IoT are covered in Reference [4], specifically the requirement for a single architecture that can support many application layer standards for interoperability. The suggested architecture, which is based on RESTful services, recommends developing a uniform API to guarantee that devices follow a standard framework, fostering interoperability throughout the entire Internet of Things network.

3.4. CLINICAL APPLICATIONS

Most of the clinical scenarios covered in the articles deal with ailments that affect senior citizens and elements of aging in a healthy way. Particularly, home-based rehabilitation, orthopaedic and cardiac care, sports rehabilitation, kinesiotherapy, and assistance for wheelchair users are among the topics covered in the cases studied in physical medicine and rehabilitation. Particularly, stroke has become the condition that is studied the most when technology is used. Though some problems might be pertinent to paediatric populations, children's technology-assisted rehabilitation was not included in the studies. Sophisticated IoT systems that combine inference engines and Machine Learning algorithms are being employed in a variety of clinical contexts to improve diagnosis and treatment [54]. The development of platforms to support health services—like Health-IoT systems that include discrete biosensors, smart packaging, and smart medicine boxes—illustrates how important IoT is to daily health management and how it may be integrated into specific health care procedures.

3.5. DESIGN AND ARCHITECTURE

According to the studies, patients who are performing at-home exercises should receive remedial feedback, especially if it is given in real time when mistakes are made. Incorporating patient feedback into the development process and using a user-centred design approach are crucial, and design methods should be focussed on recognizing the unique demands and challenges of users based on their experiences with technology. The process of developing a gadget that efficiently aids in daily care is extremely intricate and challenging. It is critical to attend to each patient's unique demands in a variety of settings.

4.CONCLUSIONS

To give IoT application developers a starting point, this article has outlined the four main kinds of Internet of Things (IoT) services and supplied examples for each. Web Services and access gateways are being used by a lot of developers to communicate with different terminals. In the meantime, there is an increasing trend toward the adoption of IPv6, which makes it possible for more devices to connect directly to the internet using their own IP addresses as opposed to being a part of a subnetwork that is connected via a gateway. Even with these developments, a great deal of work needs to be done to combine all of these services into a smooth, allencompassing system that permits communication for everyone, everywhere, at any time. Numerous significant findings are revealed by the meta-analysis of research methodologies used in intellectual property (IP) studies. Firstly, a range of procedures are utilized, encompassing mixed-methods, quantitative, and qualitative approaches. While case studies and interviews provide important insights into the socio-cultural dimensions of intellectual property, quantitative methods such as econometrics and patent data analysis are frequently used in empirical research. Research outputs are becoming more reliable when findings are combined through the use of mixed methods methodologies. Second, methodological rigor and triangulation are crucial in IP research, as each methodological approach has advantages and disadvantages of its own. Third, new developments that are impacting the future course of IP research include globalization, interdisciplinary cooperation, and technical advancements. Overall, the meta-analysis highlights how IP research is dynamic and how novel approaches are required to address challenging problems in this rapidly developing field. This meta-analysis has important ramifications for upcoming IP research. First, given the complexity of intellectual property concerns, academics ought to take a multidisciplinary approach, incorporating ideas from the domains of law, economics, sociology, and psychology. Second, to use new technologies in IP research, such as big data analytics, machine learning, and computational modelling, methodological innovations are required. Thirdly, enabling cross-study comparisons and meta-analyses requires enhancing data availability, quality, and interoperability. To increase the validity of IP research findings, researchers should concentrate on improving open science, replicability, and transparency. Lastly, given the current state of globalization, digitization, and technological innovation, it is imperative that future research examine the ethical, social, and cultural effects of IP rules and practices. Several suggestions for IP practitioners and legislators can be made in light of these findings. First, in order to obtain a thorough understanding of IP concerns, practitioners should be aware of the advantages and disadvantages of different research approaches and, when appropriate, employ a mixed-methods approach. In order to promote evidencebased policymaking and regulatory reforms in fields like patent law, copyright, and trademark protection, governments should also collaborate with interdisciplinary research teams. Thirdly, in order to foster knowledge exchange, capacity building, and technology transfer in the IP sector, cooperation between practitioners, academic institutions, research organizations, and industry partners should be fostered. In the digital age, regulators should also create standards, best practices, and ethical guidelines to handle emerging issues like data privacy, algorithmic prejudice, and intellectual property infringement.

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